SECTION 1

DSCS OVERVIEW

The Distributed Show Control System (DSCS) is a collection of layered networks and components used to perform playback, monitoring, and control of all show elements in the Toyko DisneySea attractions.

The DSCS is modular and scalable so it fits a wide range of park attraction sizes and requirements. The system distributes control devices throughout the show areas, placing them close to the devices they control.

The DSCS architecture offers the following benefits.

Minimizes facility impacts by:

- distributing Input/Output (I/O) to reduce equipment room space requirements
- minimizing cabling requirements
- easily accommodating show scope changes

Reduces engineering/manufacturing costs by:

- providing scalable architecture
- simplifying the system configuration
- minimizing cross-connect (wirelist) requirements
- reducing installation time and costs

Improves system performance, which improves show quality, by:

- minimizing servo loop cabling distance (control electronics placed near animation)
- improving servo algorithms
- tightening servo loop control timing
- improving maintenance and diagnostic features

1.1 WHAT S IN THIS MANUAL

This manual describes the components that make up the DSCS, lists the elements and devices that DSCS controls, and explains how DSCS controls them. This manual provides information about the operation and maintenance of the DSCS in the Distributed Show Control System (DSCS) at Toyko DisneySea.

This section offers an overview of the Distributed Show Control System (DSCS) and its components.

Section 2 describes the DSCS hardware and software.

Section 3 explains what DSCS controls and how it works.

Section 4 contains operating instructions for running the attraction.

Section 5 gives maintenance procedures and tips to help technicians troubleshoot and repair the DSCS.

Section 6 provides system/equipment assembly drawings, schematic or interconnect diagrams, wire lists, and wiring diagrams.

Section 7 offers a Manufacturer's Contact List and technical information from manufacturers that describes systems and equipment used in the DSCS.

Appendix A discusses the Ethernet network used by the DSCS.

Appendix B explains the PC/104 used in Interface Control Units (ICUs).

Appendix C describes DMX-512 recommended practices.

Appendix D contains an in-depth explanation of the Remote Input/Output Unit (RIOU) which is one of two types of Interface Control Units used in the DSCS.

This manual also provides a Glossary of terms and acronyms used in this manual and an Index to help you find the information you are looking for quickly.

1.2 DSCS SYSTEM ARCHITECTURE

The Distributed Show Control System (DSCS) employs an architecture of centralized data management and distributed Input/Output (sometimes called DIO). The system is divided into layered networks that connect component systems where each one is arranged, both logically and physically, to allow the greatest flexibility and ease of configuration.

The DSCS takes optimum advantage of the potential benefits of a distributed system by placing equipment in locations appropriate for their functions. For example, the electronics needed to interface with an animated figure is packaged as a self-contained unit that mounts on, or near, the animated figure. Similarly discrete I/O modules are located near devices they control to minimize hardware, cabling, and facilities costs.

1.2.1 DSCS Networks

The DSCS uses a multi-layered network structure. Components reside on specific network layers based on their role in the overall system. This section contains a description of each network layer and the components that each one supports. See Figure 1-1 “Animation Network Structure,” on page 1-4 for a high-level diagram of the network structure.

Figure 1-1. Animation Network Structure

1.2.1.1 Parkwide Network — Level 3 Network

The Level 3 network is the top level Parkwide System Ethernet backbone (PICnet). The show/ride message system is on this network, and serves as the gateway between the DSCS and the Parkwide system. For show purposes, the PICnet is used primarily for non-realtime communications between the DSCS and CNS via the show/ride message system.

1.2.1.2 Show/Ride Network — Level 2 Network

The Level 2 or show/ride network is shared by both the show and ride systems and is local to and accessible within the attraction only. It serves as the communication link between the one or more show playback computers, the show monitor computer and the show/ride message system. The show/ride network uses Ethernet and is intended for non-real-time communications.

The ride control system resides on the show/ride network for access to the show/ride message system.

1.2.1.3 Animation Network — Level 1 Network

The Level 1 or animation network links together the show playback computer (SPC), the show monitor computer (SMC), and the interface control units (ICUs). In addition, the animation programming computer system (APCS) and maintenance interface units (MIUs) connect to this network so they can communicate with the show playback computer.

The primary traffic on the animation network is transmission of real-time animation data. This data flows between the show playback computer and ICUs, MIUs, or APCSs. To ensure that all necessary communications occur in real-time, the animation network is deterministic.

In addition to transmitting animation data between the show playback computer and ICUs, the animation network gives the show monitor computer access to the ICUs to allow shared I/O capabilities.

To accommodate shows with requirements that exceed the abilities of a single show playback computer or animation network, the DSCS supports multiple show playback computers. By design each show playback computer has a separate animation network. The show monitor computer has access to each animation network via a separate interface.

The animation network allows a theoretical total of 255 nodes to be connected. However, the practical capacity of the network is less due to the requirements for real-time communications. A timing analysis has been performed on specific show configurations to ensure all necessary data can be transmitted in real-time.

At a minimum, the animation network supports 50 nodes, including the show playback computer, show monitor computer and up to four APCS computers, while updating 400 animation channels.

1.3 COMPONENT SYSTEMS

1.3.1 Show/Ride Message System

The show/ride message system, located in attraction electronic equipment rooms (EERs), is the gateway between the show and ride control systems and PICnet. The message system receives message and status information from the show and ride control systems via the show/ride network. It logs messages locally as well as forwarding specific messages on to the central network station (CNS) for central reporting.

The message system archives messages for as long as one year for subsequent analysis. The show/ride message system allows optional operator terminals and displays to be installed at locations specified by operations and maintenance. These devices interface with the message system via the show/ride network.

In addition to message management the message system shall have resident network analysis/diagnostic software for the purpose of monitoring and maintaining the PICnet and show/ride networks.

1.3.1.1 SRMS Interfaces

The show/ride message system supports interfaces to the following networks and subsystems:

- **PICnet**

  Provides the communication path for central network station (CNS) status reporting and provides firewall protection for the show and ride systems.

- **Show/Ride Network**

  Provides interface to show playback computers and show monitor computers for status reporting and diagnostics.

1.3.2 Show Monitor Computer (SMC)

The show monitor computer is located in the attraction Electronic Equipment Rooms (EERs). It is responsible for high-level supervisory monitor and control of the DSCS. This includes performing the logic necessary to support maintenance and operator interfaces required for show operation. The show monitor computer also monitors the integrity of the show system and can take action if problems occur.

The show monitor computer is used primarily for functions common to the operation of the entire show system. If localized control/logic functions are required for specific subsystems (such as a hydraulic pump), those functions are implemented using a dedicated controller (typically a PLC) specific for the task. Such dedicated controllers interface to the show monitor computer for the purpose of high-level system control and monitoring.

The show monitor computer is a PC running a third party “off the shelf” industrial control software, utilizing a fifth-generation programming environment.

A touch sensitive screen is provided in the cabinet for the purpose of navigating the various screens designed to perform control and diagnostic functions, including show start-up operations. Optionally, a remote show start-up panel (RSSP) with a touch sensitive screen is provided when show start-up must be performed at a location away from the show monitor computer.

1.3.2.1 SMC Interfaces

The show monitor computer supports interfaces to the following networks and subsystems:

- **Show/Ride Network**

  Provides the interface to the show/ride message system for local status reporting and diagnostics. Status reporting to the central network station (CNS) is exchanged via the show/ride message system and PICnet.

  Provides high-level control and status of the show playback computers. Not intended for real-time control, but rather show start-up type functions (such as enabling triggered/continuous/SMPTE scenes, stopping/resetting scenes, and so on).

- **Animation Network**

  Provides for communication between the show monitor computer and ICUs. There is a separate interface for each animation network configured in an attraction’s DSCS. Using RIOUs, this network allows the show monitor computer to interface with equipment such as hydraulic pumps, animation air valves, and architectural lighting systems.

1.3.3 Show Playback Computer (SPC)

The show playback computer is located in the attraction EER. It is responsible for coordinating and synchronizing the elements of a show presentation. Each show playback computer is capable of controlling a minimum of 400 animation channels and up to 255 animation scenes. Multiple show playback computers are used as necessary to satisfy each attraction's requirements.

1.3.3.1 SPC Interfaces

The show playback computer supports interfaces to the following networks and subsystems:

- **Show/Ride Network**

  Provides status to the show monitor computer and allows the show monitor computer high-level, non-rea-time control of the show playback computer (such as enabling/stopping/resetting scenes and so on).

- **Animation Network**

  Provides for real-time communication between the show playback computer and ICUs, APCSs, and MIUs. The show playback computer uses this network to transmit animation data in real-time to the ICUs and receive data from the APCSs and MIUs.

  A separate animation network is required for each show playback computer.

- **DMX-512**

  Allows show playback computers to directly control lighting dimmers and other lighting and special effects devices.

- **SMPTE Time Code**

  The master time reference provided by the audio system and used to synchronize the DSCS show playback computers with each other and to non-DSCS systems (such as lighting, audio/video, projection, and so on). SMPTE is serial data that provides time-position information by way of an incrementing absolute frame count.

1.4 INTERFACE CONTROL UNITS (ICUs)

The DSCS offers two types of ICUs:

- Remote Figure Interface Unit (RFIU)
- Remote I/O Unit (RIOU)

1.4.1 Remote Figure Interface Unit (RFIU)

The RFIU is the control device used for animations that require electrical feedback servo control (typically AudioAnimatronic figures). The RFIU is comprised of analog input/output modules (called mFSC cards, or multichannel feedback servo control cards). These modules provide control for a minimum of eight triple-action analog functions and a minimum of eight digital functions. An appropriate number of RFIUs are used for each animated figure, depending on the number of functions a figure performs. For figures with limited animation, multiple figures may share the same RFIU.

The algorithm to close the servo loop is performed by the microcontroller within the RFIU. Multiple algorithms are allowed to permit different algorithms to be selected for different configurations. One of these options is open loop control. Algorithm selection is part of the RFIU configuration data accessible via the maintenance interface unit (MIU).

The physical size of the RFIU is important. It is packaged as compactly as possible to allow it to be mounted on, or beside, the figure it controls.

1.4.1.1 Analog Control

The RFIU supports the following analog effector devices:

- Hi-current coil valves (drive: ±400 mA full scale)
- Low-current coil valves (drive: ±60 mA full scale)
- Bipolar direct drive valves (drive: ±10 VDC / ±5 VDC)
- Unipolar direct drive valves (drive: 0-10 VDC)

Certain direct drive valves require a constant supply voltage (typically 24 VDC) with varying current draw depending on flow rate, pressure, and so on. Provisions are made to accommodate these types of valves.

The RFIU supports the following analog sensor devices:

- LVDT/RVDT (excitation: 5 Vrms @ 2600 Hz feedback: 0-5 Vrms @ 2600 Hz)
- Rotary & linear potentiometers (excitation: 10 VDC feedback: 0-10 VDC)
- Hall effect sensors (excitation: 5 or12 VDC @ 30 mA feedback: 2-4 VDC)
- Strain gauge sensors (excitation: 10 VDC @ 100 mA feedback: 0-5 VDC or excitation: 24 VDC @ 120 mA feedback: 0-10 VDC)
- Pressure transducer (excitation: 24 VDC feedback: 0-5 VDC)
- Magnetostrictive linear position transducers (excitation: 24 VDC feedback: 0-10 VDC)

Any combination of sensor types, can be configured as required for each animation function. There is no hardware correspondence between a physical sensor input and its associated valve driver. The logical association of inputs to output are a configuration parameter for each function.

All excitation outputs are overload protected using self-restoring devices rather than replaceable fuses.

1.4.1.2 Digital Control

The digital outputs are provided for controlling the digital functions required by animated figures. Each output is capable of driving loads requiring 24 VDC up to 150 mA. All digital outputs are optically isolated and overload protected using self-restoring devices rather than replaceable fuses.

No digital inputs are provided.

1.4.1.3 RFIU Interfaces

The following interfaces are provided:

Animation Network – The deterministic network used to receive show data in real time from the show playback computer and show monitor computer. It returns status and position data to the show playback and show monitor computers.

In addition, it provides the means of setting and accessing configuration data for analog functions, as well as performing diagnostic functions using the maintenance interface unit (MIU).

The RFIU design allows the network to be “daisy chained” from one RFIU to the next.

1.4.1.4 Controls & Indicators

The following controls are provided on the unit:

- Power Switch – Controls the supply power entering the RFIU.
- Node Address – Selects the node address for the RFIU.

The following indicators are provided on the unit:

- Power On – On when unit is powered.
- Processor Active – Blinks to indicate the RFIU processor is active.
- Network Active – Blinks to indicate the animation network is active.
- Duplicate Node – On when another node with a duplicate address is on the network.
- Fault – On to indicate fault condition.

1.4.1.5 Power Source

DC power for the RFIU will be sourced from an external power supply located adjacent to the animation hub which serves the RFIU. A power cable will run from the power supply to each RFIU. RFIUs which have their network connections daisy chained can also do so with the power source up to the limit of the current that can be sourced from the cable.

It is permissible to provide all required voltages from the external power supply. Or alternatively a single raw supply voltage can be provided and the specific voltages required can be derived within the RFIU.

1.4.2 Remote I/O Unit (RIOU)

The RIOU is the ICU for show elements that require discrete I/O control. I/O modules are available that provide control of digital and analog (open loop) functions.

The RIOU does not support closed loop servo control.

Both AC and DC input and output modules are available. The RIOU employs an industry standardized, multi-sourced I/O subsystem (such as Opto22, Gordos, Grayhill, and so on) adapted to interface to the animation network.

The RIOU offers packaging options that accommodate the following I/O configurations:

- up to 32 digital I/O modules
- up to 24 digital I/O and 8 analog output modules

In addition to providing I/O module termination for field devices, the RIOU provides the capacity to terminate up to 10 pairs of field wiring. This field wiring must not terminate on an I/O module, but be cross-connected to the multi-conductor cable that is connected to the animation hub. This offers the ability of routing discrete signals in a “hard-wired” fashion to other points within the DSCS.

1.4.2.1 RIOU Interfaces

Animation Network

The network used to receive show data in real time from the show playback computer and show monitor computer. The animation network transmits input module data and status back to the show playback computer and show monitor computer.

It also provides the ability to perform diagnostic function using a maintenance interface unit (MIU).

The RIOU design allows the network to be daisy chained from one RIOU to the next.

1.4.2.2 Controls & Indicators

The following controls are provided on the RIOU:

- Power Switch – Controls supply power entering the RIOU.
- Node Address – Selects the node address for the RIOU.

The following indicators are provided on the unit:

- Power On – On when unit is powered.
- Processor Active – Blinks to indicate the RIOU processor is active.
- Network Active – Blinks to indicate the animation network is active.
- Duplicate Node – On when another node with a duplicate address is on the network.
- Fault – On to indicate a fault condition.

1.4.2.3 Power Source

All necessary power supplies are located within the RIOU and are powered from the facility AC line.

1.5 DSCS NETWORKS

The following sections describe the interconnections of the various networks.

1.5.1 PICnet

The Parkwide system provides a hub within the EER to attach to the PICnet. The show/ride message system attaches to this hub.

1.5.2 Show/Ride Network

A network hub is located in the EER for the purpose of distributing the network signals between the show/ride message system and the show playback computers, show monitor computer, and ride control system.

1.5.3 Animation Network

A network hub is located in the EER for each of the animation networks. It serves as the distribution point for the animation network within an attraction. An appropriate number of hubs are located in each show scene to support the ICUs located within the scene.

A single network cable connects the EER hub to the scene hub. In the event a scene requires multiple hubs, they are connected in a cascading fashion. That is, the EER hub serves one scene hub. That scene hub serves the second, which in turn serves the third, and so on. It is possible to cascade hubs at least five deep. Cable lengths up to 200 meters (700 feet) are allowed between hubs.

In the event an ICU must be located outside of the building, lightning protection is provided to protect the network. A hub version is available with lightning protection. One such hub is located within the building near the location that the network cable exits the building. A second lightning-protected hub is located near the ICU outside the building.

Fiber optic cable may be used for external installations. In such cases, hubs with fiber optic capabilities may also be used.

1.5.3.1 Animation Network Hubs

Animation network hubs are mounted in wall mount enclosures offering two basic configurations:

- Up to 8 ports
- Up to 24 ports

Facility power is supplied to hub enclosures. A hub enclosure also provides cross-connect capability of multi-conductor cables that terminate at the hubs as described in Section 1.5.4.

1.5.4 Hard-wired Signal Distribution

Occasionally signals must be “hard-wired” from one point to another and not rely on the network. This can be required for various reasons, such as safety (an equipment E-stop) or when a signal data format not appropriate for the Ethernet networks (such as SMPTE or DMX-512 data).

To accommodate the need for distributing or routing non-networked signals within the DSCS, the cabling/termination scheme provides the ability to selectively cross-connect signals within the DSCS cable plant (see Figure 1-2).

A quantity of spare, undedicated wire pairs are provided in the cable, along with the animation network signal. Cross-connect capability is provided at the animation hubs as well as at RIOUs for the purpose of routing specific signals between points within the DSCS.

Figure 1-2. Hydraulic Pump E-stop Example

Figure 1-2 illustrates an example of wiring E-stop buttons to a hydraulic pump. Figure 1-3 “SMPTE Distribution Example,” on page 1-15 below shows an example of distributing SMPTE to show playback computers and projectors.

Figure 1-3. SMPTE Distribution Example

1.6 INTERFACES TO OTHER SYSTEMS

1.6.1 Animation Programming Computer System (APCS)

An APCS is used to program the animation controlled by the show playback computer. In order to support the real-time requirements of the programming system, the APCS uses the animation network. Simultaneous use of multiple APCSs on one animation network is supported.

The DSCS is capable of playing back previously programmed animation sequences while receiving and merging data from the APCS. The show playback computer handles data and timing coordination for this task.

1.6.2 Ride Control

The interface to ride control is primarily to receive vehicle triggers or other cues related to ride activity. An RIOU is mounted within or next to to the ride control system to collect the discrete triggered cues. (See Figure 1-4 “Ride System Interface,” on page 1-17.) If the DSCS is configured with multiple show playback computers, then a corresponding quantity of RIOUs are used as necessary to provide each show playback computer with its necessary information.

The ride control system also has an interface to the show/ride message system via the show/ride network. Ride control components include:

- ride control computer
- an optional ride monitor computer
- any message system monitors and terminals specified by ride control engineering

Figure 1-4. Ride System Interface

1.6.3 Audio/Video (A/V)

The interface to the audio/video (a/v) system utilizes the animation network due to the real-time communication requirements between the DSCS and a/v system. If the a/v system does not have a direct interface to the animation network, then an RIOU is mounted within or adjacent to the a/v system to provide this interface. See Figure 1-5 “Audio/Video System Interface,” on page 1-19.

If the DSCS is configured with multiple show playback computers, a corresponding quantity of RIOUs are used as necessary to provide each show playback computer with a separate interface.

The DSCS often issues digital start cues to the a/v system to start various audio and video tracks during the show cycle. Additionally, audio tracks may need to be cross-faded or dimmed as part of the show presentation. These are typically analog commands that originate from the DSCS. Any command and status signals required for start-up purposes or other overall control requirements are also passed via the RIOUs.

Figure 1-5. Audio/Video System Interface

1.6.4 Lighting

There are two aspects of interfacing the DSCS with the lighting system:

- Direct DSCS control of show-controlled dimmers.
- An interface to the lighting controller that allows the DSCS to issue timing cues.

For details, see Figure 1-6 “Lighting System Interface,” on page 1-21.

Show-controlled dimmers are controlled using the DMX-512 protocol. The show playback computer can output DMX-512 data for the purpose of controlling light fixtures that require show-controlled dimming but that are not controlled by the lighting controller. For example, special effect lighting. Also, certain special effect strobe lights can be controlled directly via DMX-512.

The second interface is to the lighting controller; an independent system programmed by the attraction’s Lighting Designer. For convenience the lighting controller has been configured as part of, and is housed within, the DSCS. All interfaces and cabling requirements are part of the DSCS.

The DSCS sends timing cues to the lighting controller in real-time, therefore the interface must utilize the animation network. If the lighting controller does not have a direct connection to the animation network, an RIOU is mounted within or next to the lighting controller. The RIOU can then provide the DMX-512 interface in the form of discrete I/O. If the DSCS is configured with multiple show playback computers and/or multiple lighting controllers are required, a corresponding quantity of RIOUs are used to provide the necessary control.

Figure 1-6. Lighting System Interface

1.6.5 Externally Sourced Animation Data

The show playback computer (SPC), via the animation network, can receive external, asynchronous animation data and merge it into transmitted data packets along with the preprogrammed data to control the animation. This feature can be used by live entertainers and guests for real-time interaction with certain animation and show elements.